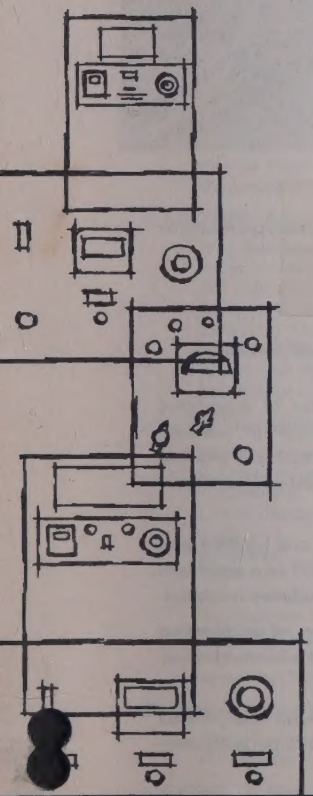
P 14556

MP MASTER
MA30065

# INSULATION RESISTANCE

## Measurements

## with the VIBROTEST®

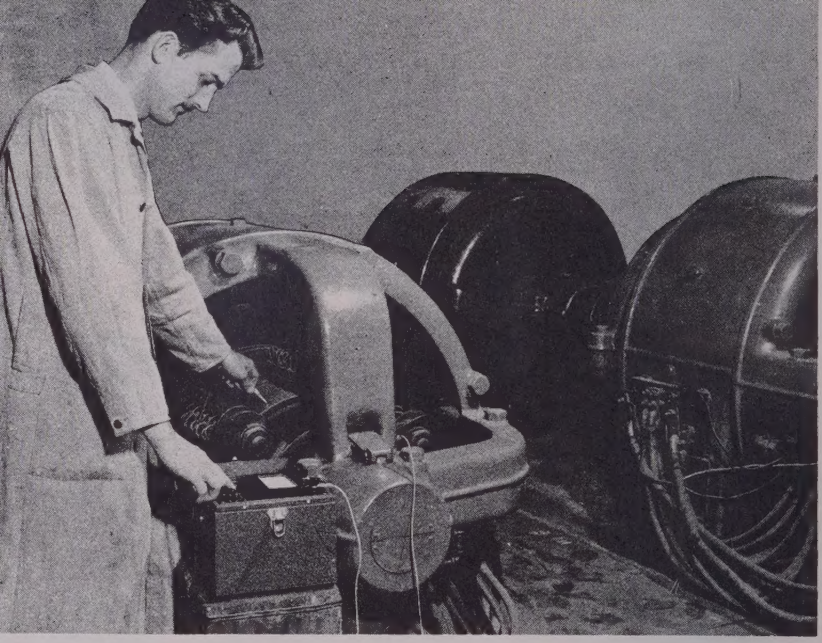


Model 201

ASSOCIATED RESEARCH, Incorporated
3758 WEST BELMONT AVENUE • CHICAGO 18, ILLINOIS

INSTRUMENTS for measuring:

- Insulation Resistance . . the VIBROTEST®
- Ground Resistance . . the VIBROGROUND®
- Earth Resistivity . . the VIBROGROUND®
- High Voltage Breakdown, AC-DC . . the HYPOT®



*VIBROTEST measurement of resistance between commutator on d-c generator and ground (frame).*

## "Push Button" Resistance Measurement

**Over twenty years ago, James F. Inman, founder of Associated Research, Inc., created the first VIBROTEST "push button" resistant measuring instrument. This original model of the VIBROTEST attained laboratory accuracy for resistance measurements previously unknown in direct reading instruments.**

**Such advanced features as elimination of cranking and leveling plus light weight, compact design . . . marked the VIBROTEST as a significant advance in the design of instruments for measuring insulation resistance.**

**VIBROTEST designs of today embody twenty years of engineering refinement plus incorporation of facilities to meet the needs of many specialized applications.**

**Among the latest VIBROTEST developments are models that provide push button measurement of insulation resistance to FIVE MILLION megohms. Descriptive bulletins available on request.**

# VIBROTEST®

## Insulation Resistance Measurements

# TABLE of CONTENTS

## Operating Instructions and Application Data


**How the VIBROTEST Operates**

- Megohm Ranges 4
- Ohm Ranges 6
- Voltage Ranges 6

**VIBROTESTING**

- How to Prepare for Tests 7
- Operation of the VIBROTEST 7

**VIBROTEST Applications**

- Why Insulation Testing is Important 11
- What is "Good" Insulation Resistance 12
- The One Megohm per 1,000 Volts Rule 12
- Acceptable Resistance Values According to Current Flow 12
- Testing at Ambient Temperatures 13
- Shortcut to Cold Testing 14
- Where and What to Test 15
- Importance of Record Cards and Periodic Testing 16

**VIBROTESTING Specific Equipment**

- Wiring 18
- D-C Motors and Generators 19
- A-C Motors 19
- Circuit Breakers 20
- Switches 20
- Insulators 21
- Capacitors 21
- Appliances 22
- Transformers 23
- Flooded Equipment 23
- Network Testing 25
- Inspection Testing 26

**Dielectric Absorption**

- Using Dielectric Absorption in VIBROTESTING 27
- Polarization Index 27

**VIBROTEST Maintenance**

- Batteries 28
- Vibrator 29
- Infinity Setting of Pointer 29
- Fuse 29
- Accidental Damage 30
- Warranty 31

## MEGOHM RANGES

The megohm range of the VIBROTEST gives a direct reading of the millions of ohms of resistance which any electrical insulation offers to the passage of current.

The high voltage across the VIBROTEST terminals is built up from 3 volts supplied by the two heavy duty dry cells in the unit. This is accomplished by changing the battery current to alternating current by means of a synchronous vibrator "V", and applying it to the transformer "T" which steps it up to a higher value.

This higher a-c voltage is then sent back to the synchronous vibrator which rectifies it to direct current. The resulting direct current is fed to the voltage doubler "C" (which also acts as a filter to reduce the output ripple), reaching the terminals through the metering circuit.

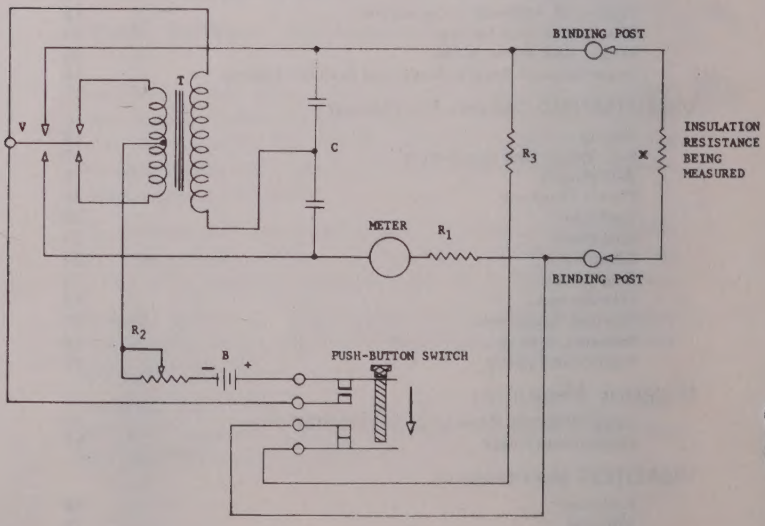



***Figure D—Simplified Schematic of Typical Battery Operated VIBROTEST***

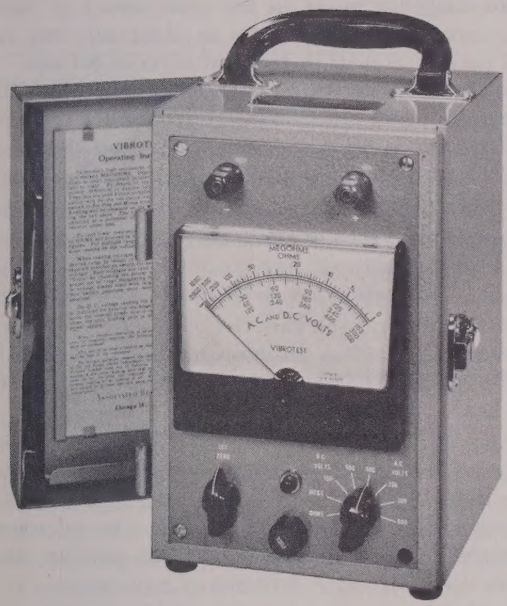



***Figure E—Model 201 VIBROTEST***

When the push button is pressed to the midway position a set of contacts connects the meter "M" and the series resistor "$R_1$" across the high potential output so the full output is fed to the metering circuit, which now is acting as a voltmeter.

At this time, rheostat "$R_2$" will adjust the primary input voltage to transformer "T" to allow the meter pointer to be set to full scale (zero resistance point). This automatically adjusts the output voltage to its proper value.

Depressing the push button fully places the unknown resistance "X" (connected across the binding posts) in series with the meter and "$R_1$". The current then flowing through the meter is determined by the insulation resistance "X", "$R_1$" and "M". Since the meter calibration and the zero adjustment compensates for "$R_1$" and "M", the point on the meter scale where the pointer comes to rest is dependent only on the amount of current now flowing through "X". Calibration is such that the meter will indicate in megohms, the true value of the insulation resistance "X".

When the unknown resistance has been measured and the push

button released, resistor "$R_3$" (which is of very low value as compared to the megohm range in the instrument) is automatically connected across the binding posts to short out any capacitance charge that may be present in the insulation under test.

An internal guard circuit is incorporated in all VIBROTEST models to by-pass panel surface leakage around the metering circuit, and an external guard connection is provided on certain models of the VIBROTEST for use when making higher megohm measurements.

Many VIBROTEST models incorporate additional circuitry to enable the meter to be used as a low range ohmmeter and as an a-c/d-c voltmeter. In this way, all measurements normally required when testing electrical equipment are available in a single instrument.

Since current drain on the batteries is low during operation and current is drawn only when the push button is depressed, the batteries may be expected to last many months even under conditions of extreme use.

Some models of the VIBROTEST have a built in voltage-regulated vacuum tube power supply for operation from 115 v, 50/60 c line. These units differ from the battery operated VIBROTEST in that the measuring circuit consists of a vacuum tube microammeter of extremely high sensitivity and stability. This permits measurement of resistances as high as many millions of megohms.

## OHM RANGES

**For measuring relatively low resistance values, one or more ohm ranges are available on most Vibrotest Models, powered directly by the three-volt dry battery source. This provides an easy means of determining the resistance or continuity of circuits in motors, relays, control box coils, and the like. Having an ohm range in your Vibrotest eliminates the necessity to carry or maintain a separate ohmmeter. In general, ohm ranges have been selected to provide a wide coverage in resistance readings. In the Model 201 particularly the 2,000 ohm range was included because of its usefulness in general plant testing.**

## VOLTAGE RANGES

A-c and d-c voltage ranges provided by the VIBROTEST are highly accurate, and are read on the same scale. Voltage ranges are selected on the single rotary switch, and are placed in such position as to be most convenient for testing circuits before switching to the ohm or megohm ranges.

Both a-c and d-c voltage ranges have a sensitivity of 1,000 ohms per volt. A-c voltage ranges have an accuracy of $\pm 3\%$ of full scale on sine-wave 60 c service. D-c voltage ranges have an accuracy of $\pm 2\%$ of full scale value.

## CAUTION

Note: Whenever you handle the Vibrotest—or allow others to use it—remember that there is a high voltage across the terminals when testing in the megohm range. Very low current flow makes the Vibrotest relatively safe, even when improperly used; but it is best to be sure no one will inadvertently come in contact with test circuit.

## HOW TO PREPARE FOR TESTS

*Shut Down.* Take equipment or circuits to be tested out of service. Check between equipment and ground on Vibrotest voltage ranges to be sure no A.C. or D.C. voltage to ground exists. If possible, disconnect all leads to unit to be tested. Where a motor or circuit is not completely isolated, make sure you know all the components which will be tested when you connect the Vibrotest. Should you overlook an interconnected circuit, the Vibrotest reading will be lower than expected

## OPERATION OF THE VIBROTEST

Open the case of your VIBROTEST and look it over carefully, using the accompanying photo-diagram (on page 9) to identify the various items and establish their functions firmly in your mind.

You may use the operating instructions in the lid for making tests, but it is suggested that you FIRST read the paragraphs which follow, carefully. These expanded instructions and applications suggestions are intended as a general introduction to VIBROTESTING . . . as well as actual operating instructions.

The cover of the VIBROTEST may be removed by opening it fully. Then, while working it gently, push the cover toward the top of the instrument, at the same time holding on to the body of the instrument. The pin hinges slide out of their sockets in the case, leaving a compact instrument, ready for operation.

Before connecting leads to terminals (1) and beginning actual testing, we suggest that you practice operating your VIBROTEST for several "dry runs" to become familiar with the use of the selector switch (4), the push button (3), and the "Set Zero" knob (6). These are the controls you will soon be using almost automatically. Complete understanding accomplished now, will save you time and insure accurate results later.

As a starter, turn switch (4) to the extreme counter clockwise position marked "Megs". With your right forefinger, depress push button (3) halfway, and you will see the meter pointer swing to the extreme right side, providing the "Set Zero" knob (6) is turned up slightly from its full counter clockwise position (which is an "off" position).

Should the meter pointer not come to rest exactly at "0" on the megohm scale with the push button halfway down, move the "Set Zero" knob with your left hand in the direction you desire the pointer to move in order to rest on "0".

After you have the meter zeroed, pushing the button all the way down applies the correct test potential across the terminals. Without the leads connected to a circuit, the resistance across the terminals is, of course, infinity. The pointer will then go directly to the " ∞ " mark, at the extreme left of the scale.

It is suggested that you now try the same procedure, but with the selector switch (4) in the "Ohms", or extreme clockwise position. Ohm readings are observed on the upper scale using both black and red figures.

You will notice that you can not switch directly from "Meg" to "Ohms". This is a built-in safety device to warn you to always check circuits to be tested for voltage, before testing for either ohms or megohms. Turning the selector switch through the voltage ranges is a simple, mechanical reminder which can save you time and trouble.

## DIRECTLY-CONNECTED VOLTAGE RANGES

It is not necessary to press the push button when using the Vibrotest to measure voltages. The meter will indicate when the selector switch is turned to one of the voltage ranges.

Be certain polarity is correct when measuring d-c voltages to avoid damaging the meter. If you are uncertain of the voltage, start on the highest range and drop to lower ranges where necessary to get the best reading.

Voltage values for both a-c and d-c ranges are read in the black figures below the meter scale.

## MEGOHM TESTS

The following is a step-by-step procedure for making megohm tests. After some practice, you should be able to set up the instrument, make the test and proceed to the next piece of equipment or circuit in less than two minutes . . . allowing a full sixty-second test period:

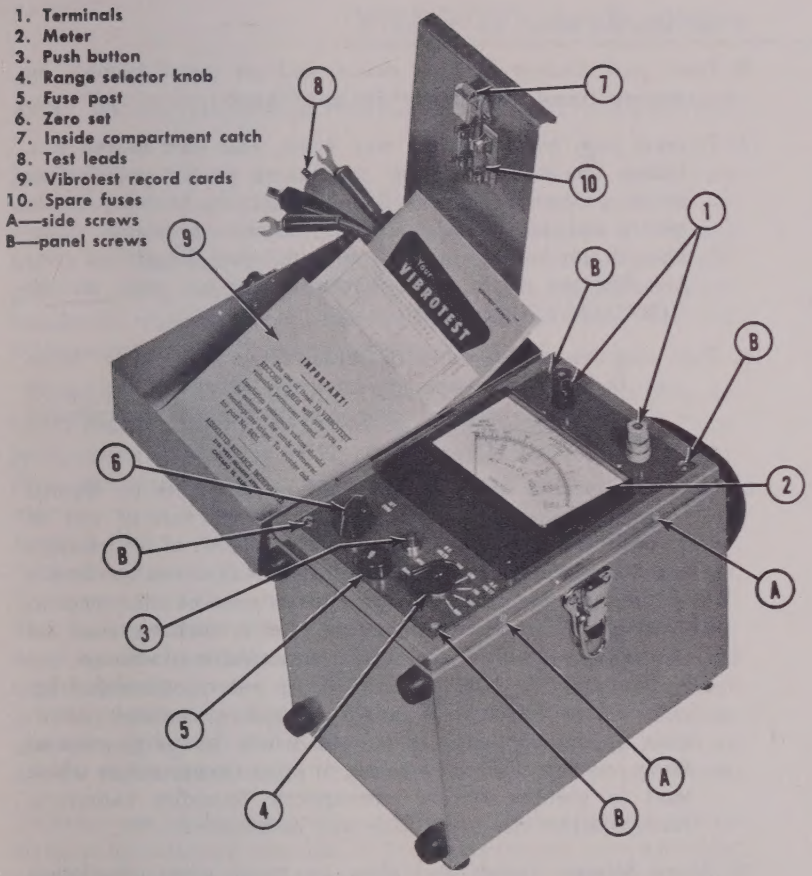



***Figure A—Model 201 Vibrotest, panel and accessory compartment***

1. Set selector switch to highest available a-c voltage range.
2. Attach leads to terminals: red lead to "+" terminal ; black lead to "—" terminal.
3. Attach lead clips to equipment to be tested. Remember that you are trying to determine the resistance value of insulation between current-carrying and non current-carrying or grounded components.
4. Check connection for voltage to ground, by working down through voltage ranges. If voltage is present, determine its source and eliminate it before attempting to check insulation resistance.
   NEVER START A MEGOHM TEST UNTIL THERE IS NO EXTERNAL VOLTAGE IN THE TEST CIRCUIT.

5. Set selector switch on "Megs.".

6. Press push button halfway down, and set meter pointer on zero (extreme right) with "Set Zero" knob.

7. Depress push button all the way down, and start timing test. Unless you are testing for capacitance or for polarization index, a 60-second test will, in most cases, be adequate to give a satisfactory indication of insulation resistance value. Should you be making tests with different lengths of time for different pieces of equipment, enter test time on the VIBROTEST Record Card.

8. Take megohm reading in black figures above meter scale. When push button is released, any capacitive charge in the circuit is dissipated through a discharge resistor that is incorporated in the VIBROTEST.

9. Take temperature and humidity reading and enter on Record Card, with megohm reading together with date of test. If you find it impossible to keep accurate records of temperature and humidity, an approximation of equivalent test conditions can be made by taking tests on a given piece of equipment as nearly as possible at the same time after it has been taken out of service, and with closely similar atmospheric conditions.
This method of VIBROTESTING is not recommended because of the difficulty of judging humidity accurately. However, if the apparatus is located where humidity remains fairly constant due to processing or other circumstances which tend to stabilize normal atmospheric humidity variations, fairly accurate results probably may be achieved.

10. Move Selector switch to highest a-c range upon completion of tests.

11. Disconnect leads and stow in lid.

## OHM TESTS

Follow the foregoing megohm procedure, Steps 1 through 4, then:

5. Set selector switch on "Ohms".

6. Depress push button halfway, and set meter pointer on zero (extreme right) with "Set Zero" knob.

7. Depress push button fully, read ohms resistance value on meter top scale, using both red and black figures.

8. Upon completion of test, move selector switch to highest a-c range.

9. Disconnect leads and stow in lid.

## WHY INSULATION RESISTANCE TESTING IS IMPORTANT

Insulation covering the various pieces of electrical equipment and wiring in your plant or product is, to the eye, inert. Its dielectric properties (resistance to electrical flow) are the reason for its use; and since good dielectric materials are also generally good wearing materials, the problem of weakening or faulty insulation resistance may easily be disregarded until valuable equipment or critical wiring systems fail in use.

Actually, electrical insulation is subject to severe stresses, even under normal operating conditions. These stresses, which cause progressive weakening of insulation value, are caused by heat, dirt, moisture, vibration, wear, aging, and even by light. An electric motor operating cycle gives a good example of these stresses. When the cold motor is started, its insulation is also cold. As the motor heats, so does the insulation, expanding under the temperature rise, and contracting when the motor is shut off. You have seen the vast power exerted by ice freezing in a confined space—bursting iron pipes or automobile radiators and engine blocks as though they were paper. This same force is present, in varying degrees, in any heated-and-cooled material; and creates strains on insulation that can eventually result in breaks which cause direct short circuits or serious power losses.

Dirt is one of the greatest enemies of insulation because almost all casually collected dust, lint, airborne grease, etc. is an excellent conductor, and capable of penetrating minute cracks and faults in electrical insulation. Keeping all electrical equipment clean is a primary rule of good preventive maintenance—and Vibrotesting is the best means of detecting hidden dirt in electrical machinery and wiring which is causing insulation deterioration.

Again with a motor as an example, let us assume that it operates in a damp atmosphere, such as encountered in many processing plants, paper mills, and the like. When it is started, the rising temperature allows the air around it to absorb more moisture; and a part of this moisture is absorbed by the insulation in the windings. On cooling, some of this moisture condenses on the insulation, and aids the expansion-contraction effects in deteriorating the insulation. Even a damp, high-humidity day creates this effect, lowering the insulation resistance of all electrical equipment—as you will discover when you Vibrotest your equipment on such a day. Of course, flooding or other accidental immersion of electrical equipment calls for special treatment in drying and cleaning.

Vibration is an ever-present hazard wherever there is operating machinery, steam lines, or even heavy pedestrian traffic. Insulation is subject to the same results from vibration as the old automobile that "actually shook itself to pieces."

Wear, aging and light deterioration are generally less severe than damage caused by dirt, water, heat and vibration . . . And all of them operate relatively slowly, but nonetheless surely, in electrical insulation.

Because of these natural "enemies" of insulation, periodic checks with Vibrotest will almost invariably predict the breakdown or dangerous weakening of any part of your electrical systems, or any piece of equipment.

## WHAT IS "GOOD" INSULATION RESISTANCE?

Safe insulation resistance in rotating machinery or other equipment may be regarded as that which is high enough to permit the equipment to operate normally . . . without excessive current consumption or heating. This is the simplest, most obvious rule to follow if you do not care to go into the formulas which may be applied to electrical apparatus to get a close approximation of what the insulation should be for safe operation. Generally, you can consider any insulation satisfactory in industrial equipment and circuits operating at 1,000 volts or less if its resistance exceeds one megohm at normal operating temperatures and humidities.

## THE ONE MEGOHM PER 1,000 VOLTS RULE

Carrying the safe minimum of one megohm per 1,000 volts a bit further, you can figure safe minimums for apparatus operating in excess of 1,000 volts by simply adding one megohm to the safe minimum for every 1,000 volts or fraction thereof. For example, if you have equipment operating at 2,500 volts, 2.5 to 3.0 megohms minimum resistance readings should be satisfactory. If your initial insulation resistance readings fall below this "rule-of-thumb" minimum, equipment should be taken out of service, inspected carefully, and necessary cleaning or repairs made to brings resistance values over the minimum reading required.

## ACCEPTABLE RESISTANCE VALUES ACCORDING TO CURRENT FLOW

Given below is a table showing minimum acceptable insulation resistance values for equipment or circuits operating at various rates of current flow. These values apply to insulation resistance

between conductors, conductors to ground, and motor or generator connections to the frame.

| Operating Current in Amperes | Acceptable Minimum Insulation Resistance in Ohms |
|---|---|
| 5 | 2,000,000 |
| 10 | 1,000,000 |
| 25 | 400,000 |
| 50 | 250,000 |
| 100 | 100,000 |
| 200 | 50,000 |
| 450 or higher | 25,000 |

## TESTING AT AMBIENT TEMPERATURES

Most insulating materials are affected in inverse proportion to the temperature at which they are being operated. This means that if you test a motor cold and get a satisfactory insulation resistance value, there is no assurance that the value will be safe at the operating temperature of that motor unless you correct for the change in resistance due to the temperature rise which occurs when motors go to work. The following formula will permit you to test motors, or other apparatus which operate above ambient temperatures, when they are cold—yet get a close approximation of what the insulation resistance value will be at normal operating temperatures.

$$\text{Log} \quad R_2 = \log R_1 - \frac{(t_2 - t_1)}{N}$$

where $R_2$ = unknown insulation resistance in megohms at temperature $t_2$.

$R_1$ = known insulation resistance in megohms at temperature $t_1$.

$N$ = constant which is equal numerically to the degrees Centigrade change in temperature for a ten to one change in insulation resistance. (Value of N will vary from 20 to 100, with the factor usually occurring between 30 and 60 for most insulating materials.) In the case of motor windings, a Class A alternating current winding can be assumed to double its resistance for each 9° C. drop in temperature. Therefore N = 30. In Class B A.C. insulated windings, insulation doubles for each 18° C. drop in temperatures. Therefore, N = 60. Direct current windings can be assumed to double for each 12° C. temperature drop. Thus, N = 40. The above-mentioned temperature constants may be used for normal commercial calculations. However, if extreme accuracy is desirable, it will

be necessary for you to set up an exact constant and establish a curve for each piece of equipment.

For example, if you have a direct-current motor which operates at 80° C. (176° F.), and you test it at room temperature of 20°C (68° F.), to get an insulation resistance of 37.6 megohms, the formula works out:

$R_1 = 37.6$ megohms
$t_2 = 80°$ C.
$t_1 = 20°$ C.

Note: to convert degrees Centigrade to degrees Fahrenheit: $°\,C = \frac{5}{9}°\,F - 32$ and $°\,F = \frac{9}{5}°\,C + 32$.

$N$ (for D.C. windings) $= 40$

Log $R_1 = 1.57519$

Log $R_2 = 1.57519 - \frac{(80 - 20)}{40}$

$= 1.57519 - 1.50000$
$= 0.07519$
$R_2 = 1.19$ megohms

As you can see, the high "cold reading" of 37.6 megohms drops to what might be a dangerously low value of 1.19 megohms when corrected for temperature rise. The fact that high humidity would further lower this value probably should lead to a decision to remove this motor for cleaning and careful inspection.

## SHORTCUT TO COLD TESTING

A shortcut many Vibrotest users take where they find it necessary to test motors cold is to figure the formula backward to secure a minimum cold reading value which will insure safe insulation resistance at operating temperatures; thus:

Assume a minimum value for $R_2$ as 3.0 megohms, with the same conditions as in the example above.

Then: $\text{Log } R_1 = \text{Log } R_2 + \frac{(t_2 - t_1)}{N}$

where $\text{Log } R_2 = 0.47712$
$t_2 = 80$
$t_1 = 20$
$N = 40$
$\text{Log } R_1 = 0.47712 + 1.50000$
$= 1.97712$
$R_2 = 94.87$ megohms

Now, instead of drawing the red "safe minimum" line on the motor Record Card at 3.0 megohms, the red line is drawn in at 95 megohms, and subsequent tests made at the same (within 4° C. or 7° F.) cold temperature, with closely approximate relative humidities.

## WHERE AND WHAT TO TEST WHEN YOU START VIBROTESTING

When you begin insulation resistance testing, every *unit* of current-carrying apparatus should be tested and a Vibrotest Record Card made of the test reading. To define what constitutes a unit for insulation resistance testing, let us assume the simplest possible motor operating circuit to consist of power input wiring, a hand-operated, double-pole single-throw switch, the wiring between switch and motor, and the motor itself. Since the power input wiring will be a part of the general wiring, we will not consider it as a part of this example. Then, the switch is the first component which may cause trouble due to insulation failure. But since the motor has several different circuits in which the insulation can fail, the easiest solution is to consider the switch and wiring from it to the motor as one unit; the motor alone as another unit. Thus, by a simple analysis of where insulation failure can occur, and how to make any potential failure easiest found, we arrive at a definition of testing units for record purposes.

Keep your test units as simple as possible, so that when trouble develops, you can locate it quickly. The extra effort necessary to disconnect various sections of grouped equipment for testing will be well repaid when weakened insulation shows up in a unit which will require only two or three tracing tests to pin down the source of potential trouble.

When you do not have records established, yet suspect that a piece of equipment may have weakened insulation resistance, you can get immediate information as to the condition of the unit by testing for its Polarization Index.

## TEST WORKING EQUIPMENT FREQUENTLY

Working electrical equipment, such as motors, generators, transformers, heating elements, relays, etc. is almost invariably more likely to develop insulation failure than wiring, insulators and other non-moving, non-cycling electrical apparatus. Therefore, your schedule of periodic insulation resistance tests should include more frequent testing of the working equipment. Four to six months between these tests is generally considered the safe maximum. Some users of the Vibrotest check all rotating machines every three months; and there are many motors operating in dirty or moist atmospheres which are checked monthly. Tests of wiring and like apparatus are usually adequate on a yearly basis unless working conditions are particularly bad.

## IMPORTANCE OF RECORD CARDS AND PERIODIC CHECKING

Unlike voltage, circuit resistance, or current flow, which can be determined positively at any given time with proper instruments, insulation resistance values which are "safe" for any given piece of equipment vary greatly. Two motors, for example, of the same horsepower, same maker, and same age, may have quite radically different insulation resistance values, yet both be in safe operating condition. Therefore, insulation resistance tests can do the best preventive maintenance job only if accurate records are kept on each piece of equipment tested; and tests are made at uniform intervals under similar conditions of operation, temperature and humidity.

## RECORD CARDS TELL THE "CONTINUED" STORY

On the Vibrotest Record Cards which came with your instrument (supplied with general purpose instruments only) one side is a graph form, having space at the top to identify the device for which the card is being made, and other pertinent data about it. The graph's horizontal lines show Vibrotest ohm readings from tests taken at dates which should be written in across the top of the graph. The five columns across the card may each represent a year, or some shorter period, depending upon how often tests are made. By plotting each test on this graph, and joining the test reading points with a line, an accurate history of the insulation resistance value of that particular device will be accumulated. Many Vibrotest users also draw a red line along the megohm value which they consider to be a safe minimum for each device, thus showing at a glance how close the Vibrotest readings are to the danger point.

On the reverse side of the Vibrotest Record Card are columns for recording pertinent data about the tests plotted on the graph. This information is important because of the variations which occur in insulation resistance readings under specific conditions at the times tests are made.

Following are several "stories" told by periodic Vibrotest readings on various devices. They will show how Vibrotesting works to save time and prevent failures in equipment.

Figure 1, Record Card "A" tells the continued story of a hard-working motor that is aging normally. Note that the first reading of 7.5 megohms was taken when the motor was installed new. Later readings, taken at approximately equal intervals of four months, show a gradual, expected decrease in insulation resistance; but with no sudden drops that would indicate trouble in the offing.

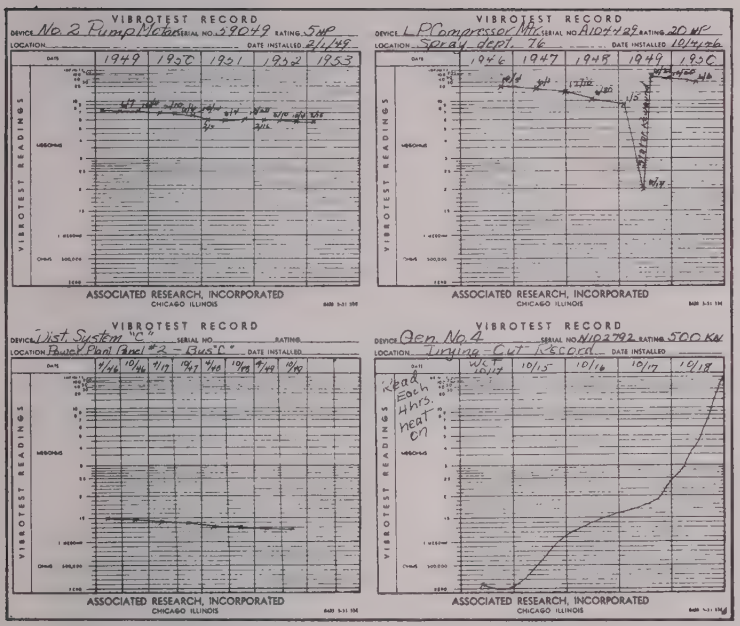

VIBROTEST RECORD
DEVICE No. 2 Pump Motor SERIAL NO. 39049 RATING 5 HP
LOCATION DATE INSTALLED 2/4/49
1949 1950 1951 1952 1953
VIBROTEST READINGS
ASSOCIATED RESEARCH, INCORPORATED
CHICAGO ILLINOIS
VIBROTEST RECORD
DEVICE L.P. Compressor Mtr. SERIAL NO. A1074725 RATING 20 HP
LOCATION Spray dept. 76 DATE INSTALLED 10/4/46
1946 1947 1948 1949 1950
VIBROTEST READINGS
ASSOCIATED RESEARCH, INCORPORATED
CHICAGO ILLINOIS
VIBROTEST RECORD
DEVICE Dist. System "C" SERIAL NO. RATING
LOCATION Power Plant Panel #3 - Bus "C" DATE INSTALLED
VIBROTEST READINGS
ASSOCIATED RESEARCH, INCORPORATED
CHICAGO ILLINOIS
VIBROTEST RECORD
DEVICE Gen. No. 4 SERIAL NO. N1P2792 RATING 500 KW
LOCATION Drying - Cut RECORD DATE INSTALLED
Read Each 4 Hrs. Heat On
VIBROTEST READINGS
ASSOCIATED RESEARCH, INCORPORATED
CHICAGO ILLINOIS

***Figure 1—Insulation Story told by Vibrotest Record Cards***

Record Card "B" tells the story of trouble with a happy ending. This motor was performing satisfactorily for the first two years, when a periodic check showed a sharp drop in insulation resistance to very close to the danger line. Inspection showed a need for new stator windings, and after they were installed, resistance values bounced back higher than the first readings taken.

Record Card "C" is what we call a System Card. It shows the insulation resistance value of a whole network of motors, starters, automatic controls and wiring. This type of record provides a quick check of a group of equipment, and is widely used to see whether any element of the system may have taken a turn for the worse between periodic checks of individual circuits and pieces of equipment. A significant drop in the insulation resistance curve on a System Card calls for individual Vibrotesting of each piece of equipment in the network until the ailing unit is located and repaired.

Record Card "D" tells the story of putting a flooded motor back to work. It is a short-term card, made during the drying-out process, and will be supplemented with a regular periodic record card after the motor is replaced in service.

Record Cards are available in envelopes of ten each and one envelope is normally supplied with most models. When ordering additional cards specify Part 8435.

While the basic principles of Vibrotesting are the same for all types of equipment, the following diagrams and brief descriptions will show you how to determine insulation resistance quickly and easily in various types of electrical apparatus.

## Wiring

Vibrotesting of wiring can be done on all types of systems if you keep two precepts in mind:

1. Be sure your wiring is de-energized.
2. Know what wiring is included in the test . . . *and make a record card of it.*

Where you have a distribution panel, you can check the whole system to ground by attaching one Vibrotest lead to the dead post of the open main power switch; and the other lead to grounded conduit. Figure 2.

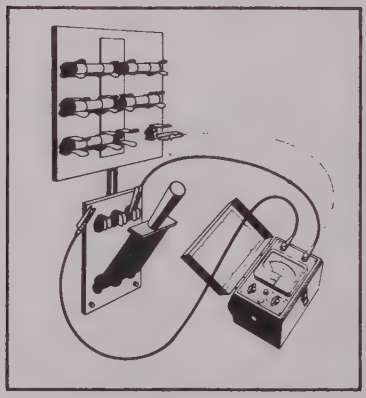


*Fig. 2—Vibrotesting a distribution panel and its individual circuits*

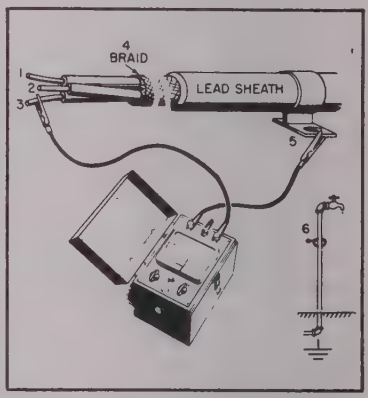



*Fig. 3—Vibrotesting multiple conductor cables*

Individual circuits are tested to ground by opening distribution panel switches or fuses and testing each circuit in turn (Figure 2 shaded lead).

Multi-conductor cables may be Vibrotested in any of the ways shown in Figure 3. The drawing depicts the measurement of insulation resistance between wire (3) and lead sheath (5). Various other measurements can be made such as wire to ground (1, 2 and/or 3 to 6), wire to wire (1, 2 or 3 to any combination of each other), wire to braid (1, 2 or 3 to 4), wire to sheath (1, 2 and/or 3 to 5).

It is well to remember that when you Vibrotest wiring which is connected to any panel or equipment, there may be appreciable leakage between terminals which will show up in your tests as lowered insulation resistance. If your original record cards were made with panels connected, continue future tests in the same manner.

## D.C. Motors and Generators

Disconnect the unit from its power source or line load and attach the negative terminal of the Vibrotest to the motor ground, with the positive terminal connected to the brush rigging. This test gives the overall resistance of all components of the unit. To read the resistance of the insulation of the field, either remove the brushes or lift them free of the commutator ring and support them by means of a suitable insulator. With the brushes lifted free of the commutator ring, connection of the Vibrotest leads to ground and to one of the brushes will give the resistance of the field alone (see Figure 5.) With the brushes still removed from the commutator ring, connection of one of the Vibrotest leads to one of the segments of the commutator and the other to ground of motor frame will give the insulation resistance of the armature alone. This may be repeated for all segments of the commutator.

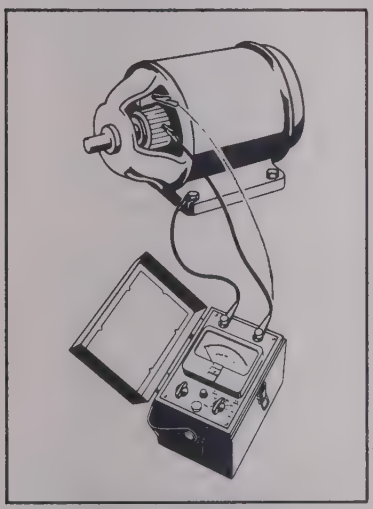


*Fig. 5—Vibrotesting direct current motors and generators*

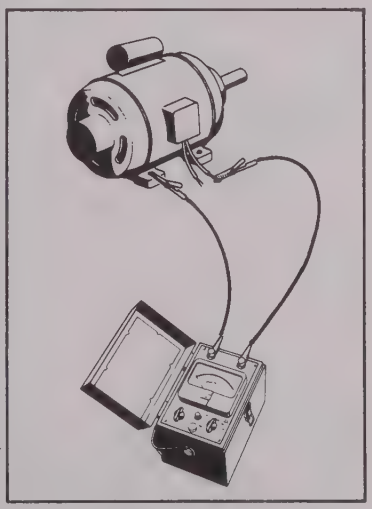


*Fig. 6—Vibrotesting alternating current motors*

## A.C. Motors

First disconnect the motor from the line, either by use of the switch or by disconnecting the wiring at the motor terminals. If the switch is used, remember that the insulation resistance of the connecting wire, switch panel and contacts will also be read at the same time. Best test is to connect the positive Vibrotest lead to the motor line, and the negative lead to the frame of the motor. (See Figure 6.)..... If insulation resistance minimums have been established, your reading may be checked against them. If you are setting your own safe standards, use the data beginning on Page 12 under "What is 'Good' Insulation Resistance" to determine whether the motor is in safe operating condition.

## Circuit Breakers

After disconnecting the circuit breaker from the line, check each terminal to ground, placing the positive Vibrotest lead at the terminals in turn. Next, open the breaker and test insulation resistance between terminals: one Vibrotest lead on each terminal. If your breakers are of the oil type, dirty oil may be causing leakage currents through the breaker even when it is open. In dry types of breakers, dirt or grease in the mounting may be causing

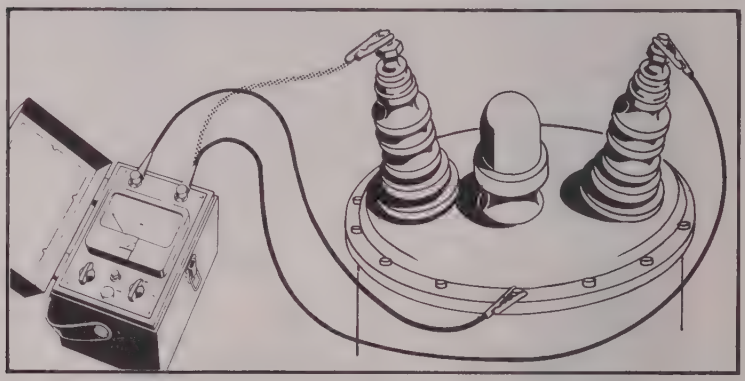


*Figure 8—Checking circuit breaker insulation resistance*

leakage. Figure 8 depicts the measurement of insulation resistance between either circuit breaker terminal to ground. This measurement should also be made between terminals.

## Switches

Switches should be *completely* disconnected from line and relay wiring before Vibrotesting. (See Figure 9, right half.) Where manual switches are being tested, make tests both from ground to terminals, and between terminals. Switches with safe insulation are a vital part of any electrical system, and so deserve your careful Vibrotesting attention. When you are testing electrically-operated switches, check the insulation of the coil or coils and contacts which operate the switch. For coils, test first with one Vibrotest lead to one of the coil leads, the other to ground. Next, test between coil lead and core iron, or solenoid element. If relays are involved, make your Vibrotest check with one lead attached to the relay plate or contact, and the other lead to the coil-core or solenoid contact. These suggestions may appear to be excessive in view of the usually-superior performance over long periods of time of most switches. . . . They are made here on the theory that one inoperative closed switch may literally wreck a whole plant system. Vibrotesting thoroughly can help to insure you against such an occurrence.

## Insulators

Insulators, the "forgotten men" of electrical systems, are subject to several ills that can make them a potential hazard unless they are periodically Vibrotested. Breakage is probably the first hazard with insulators. Casually accumulated dirt, grease or liquids is another. Rarely, faulty construction makes a brand new insulator a source of danger. To Vibrotest your insulators, connect Vibrotest leads to each end; then test each end to ground. (See Figure 9 left half.) Where insulators do not have suitable electrical contacts, wrap the ends with foil before testing.

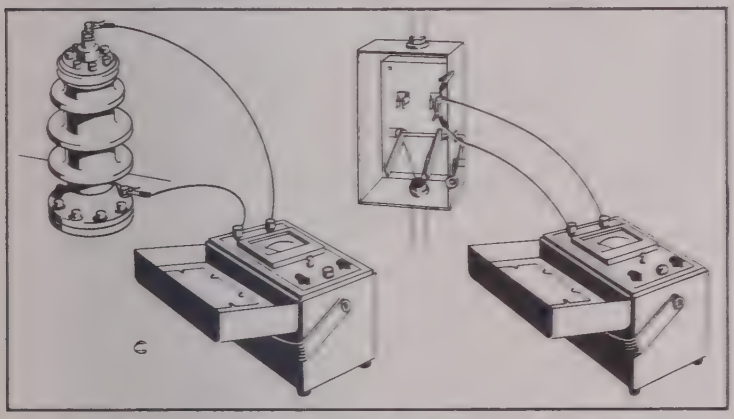


*Figure 9—Vibrotesting insulators and switches*

## Capacitors

You can use your Vibrotest to check both insulation resistance and approximate capacitance of capacitors. When you connect leads to capacitor terminals, observe polarity carefully. Time your test until meter pointer stops moving upward, then record insulation resistance at highest reading. Dividing test time, in seconds, by 15 will give you the approximate capacitance, in microfarads, of the capacitor. If the pointer has a tendency to waver toward the high reading, then drop back down the scale, the capacitor may be leaking, and further testing is indicated. Be especially careful to *release push-button* before starting to disconnect test leads from capacitors. If you do not give the Vibrotest discharge resistor an opportunity to dissipate the stored potential in the capacitance, you may get a severe shock.

## Meters

When testing insulation resistance of meter movements and cases to ground, disconnect leads to meter and connect Vibrotest positive lead to each terminal of the meter in turn; having negative Vibrotest lead connected to a suitable ground.

Meter movements themselves are generally so delicate that if you suspect leakage between elements in the meter, it is best to

remove the meter and have it checked by an instrument repair expert.

Watthour meter connections to terminal boxes should be checked from each terminal to ground after opening power circuits and removing meter from terminal box. Insulation resistance between terminal connections should then be checked to determine possible leakage.

## Appliances

Virtually all home-used appliances are operated by people without an intimate knowledge of electricity—and often without awareness of the extreme danger they may risk through faulty appliances . . . whether the danger arises through their own negligence, or through manufacturing practices. Vibrotesting of all appliances at the factory is one of the most important single precautions against merchandise returns due to unit failures, and home accidents caused by short circuits, burn-outs, or circuit

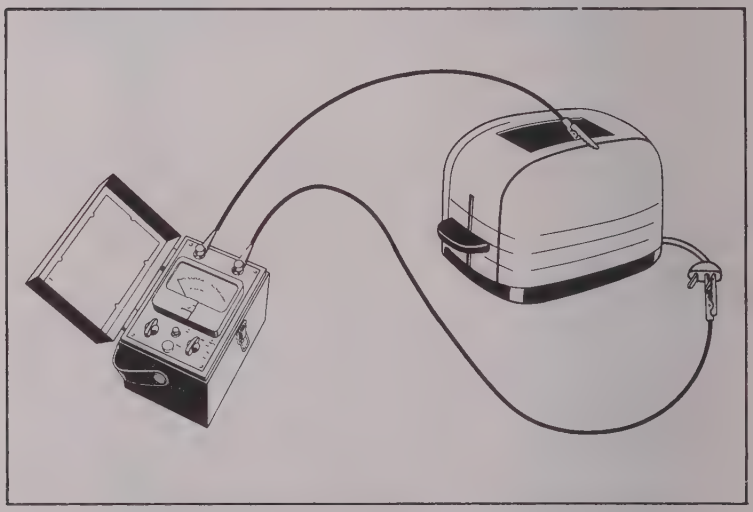


*Figure 10—Vibrotesting appliances*

failures. Figure 10 depicts the testing of a toaster. This same test can be made to other appliances by arranging the test leads in similar manner. Such Vibrotesting, where used in final inspection of various common household appliances, have already shown up thousands of faulty units which might have caused lawsuits—or death—had they been allowed to reach consumer markets.

## Transformers

Disconnect leads from both primary and secondary windings. Vibrotests can be made of either the primary or secondary winding individually by connection of the Vibrotest negative lead to an associated ground (case, metal mounting, or manmade ground), and the lead from the winding under test to the positive lead of the Vibrotest. Following Vibrotests of each winding, it is a good idea to test insulation resistance between the windings themselves. Connect one Vibrotest lead to the primary (either

*Figure 11—Vibrotesting transformers*

lead); and the second Vibrotest lead to the secondary. (See Figure 11.) All of these Vibrotests, under proper identifying labels, should be recorded on the Vibrotest Record Card.

If you have transformers with multiple-voltage windings, the procedures above should be followed to test all windings to ground, and each winding's insulation resistance value to every other winding.

## Flooded Equipment

When your electrical equipment is watersoaked—either by flood waters or accidental wetting—you are fortunate indeed when you have Vibrotest Record Cards on the ailing equipment. First, clean and dry equipment manually to the best of your resources. Then, depending upon what has been flooded, begin the recommended electrical or mechanical drying-out procedure. As soon

as it appears that actual dryness is approaching, make your first Vibrotest and record it on a new Record Card which is "red-lined" at the insulation resistance value you last read from your Vibrotest before wetting occurred. This initial reading will give you a good idea of how "wet" the equipment still may be. Depending upon this reading, make additional readings at regular intervals until the insulation resistance is approximately equal to the previous dry value. After this point has been reached, it will be safe to put the equipment back on line providing that the last "dry" reading showed safe insulation resistance. Wetting of any kind, serious enough to require unusual drying measures, should be recorded on the permanent Record Card of the equipment affected, and the "Drying-Out Card" kept on file for reference.

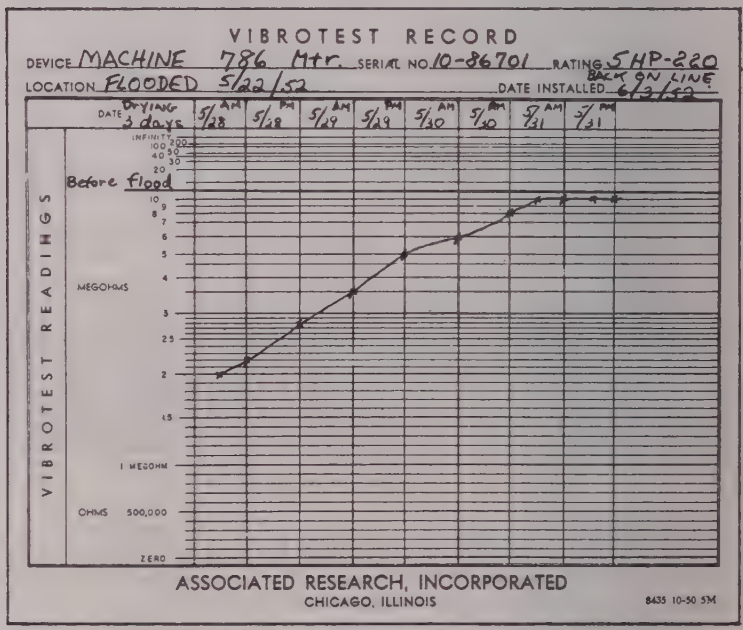



***Figure 12—Record card of flooded motor during the "dry-out" process***

Where no previous Vibrotest Record Card has been made on flooded equipment, readings should be made at intervals during the drying-out procedure until a definite "plateau" occurs in the insulation-resistance value line on the card. Such a line is plotted as shown here. (Figure 12). After the plateau stage of drying-out has been reached, Polarization Index tests should be made (see Page 27) until an Index of 2.0 or more has been reached. If equipment will not come up to the figure above, repair or overhaul is indicated.

## Network Testing

Network testing—with adequate Vibrotest information on the components of any network—provides a quick method of determining the serviceability of the system. Once you have determined that all parts of the network have safe insulation resistance values, Vibrotest from a main distribution point and record the value. Then make and record values of individual circuits which make up the network. With this basic insulation resistance information on Record Cards, you will be able to check the whole network at frequent intervals without the necessity of disconnecting each piece of equipment. Only when a significant lowering of the network insulation resistance appears will it be necessary to "work backward" through individual circuits, then

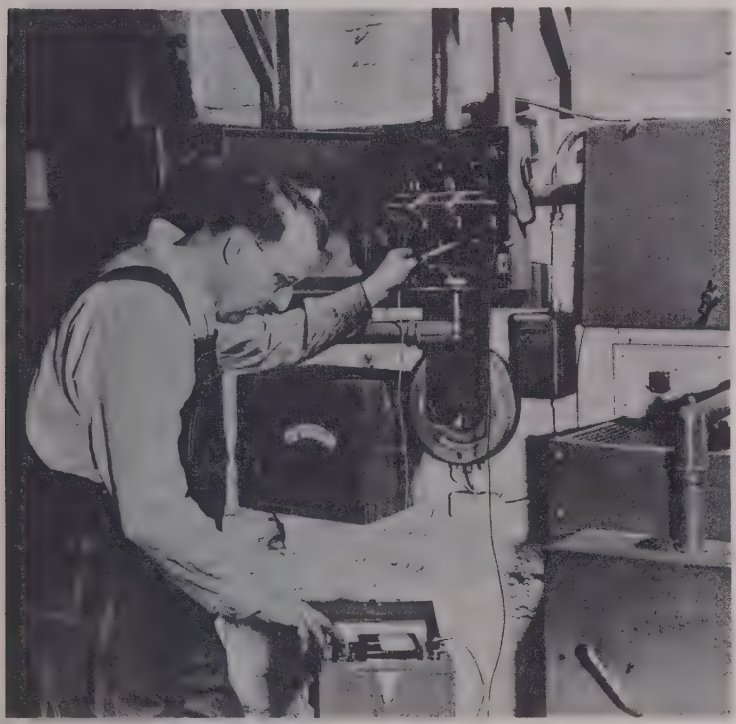


*Figure 13—Network testing*

individual units to locate faulty equipment. Figure 13 shows the testing of an entire de-energized system. A record of this measurement when compared with previous measurements denotes the condition of the network to determine if any segment is defective and should be isolated for maintenance.

## Inspection Testing

Insulation resistance testing of hundreds of different components in industry has resulted in setting up Vibrotest standards in inspection testing to protect manufacturers from the possibility of shipping out defectively-insulated products. Using the Vibrotest as an inspection-testing instrument does not vary in any respect from regular preventive maintenance tests, except that the use of the Vibrotest is usually almost continuous—and generally in one place. Continuous use in inspection testing has only proved more thoroughly the long life of all major Vibrotest components . . . and the practicality of using Vibrotests under severe service conditions.

*Figure 14—Vibrotesting motors prior to installation*

## DIELECTRIC ABSORPTION

Dielectric absorption is the actual "soaking up" of electrical current by the insulation being tested. When making standard, sixty-second Vibrotests, you will note that the meter needle is rising slowly during the test. This is the dielectric absorption gradually increasing the insulation resistance, and may be combined with capacitance charging of the apparatus being tested.

## Using Dielectric Absorption in Vibrotesting

You can make use of dielectric absorption in Vibrotesting to determine the condition of apparatus where no insulation resistance testing records exist by the "1 to 10" test, or finding the "Polarization Index" of the apparatus.

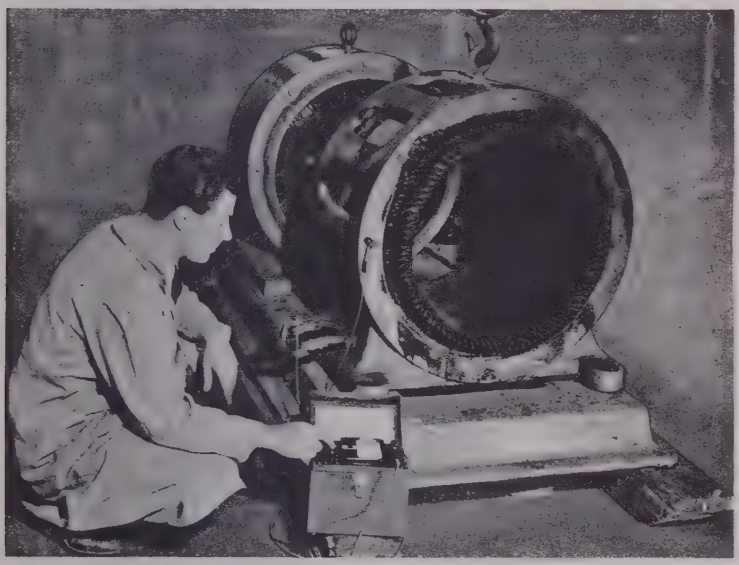


***Figure 15—Vibrotest measurement of resistance between windings and frame***

## Polarization Index

Determining the polarization index of any piece of apparatus is simple: Connect the Vibrotest, and commence timing a 1-minute test. Record the resistance reading at one minute *but continue to hold the push-button down* (or let a small weight hold it down for you), and extend the total test time to 10 minutes. The reading at the end of 10 minutes, divided by the reading taken at one minute gives you the polarization index.

For instance, if your one-minute reading on a motor is 30 megohms and the ten-minute reading 80 megohms, the polarization index will be $\frac{80}{30} = 2.67$.

Generally, a polarization index over 2.0 indicates good insulation—provided, of course, that the one-minute reading exceeds the safe minimum for the apparatus. In practice, a good polarization index is almost always accompanied by a one-minute test reading well above minimum.

## BATTERIES

Your Vibrotest is powered by two No. 6 dry cells connected in series to deliver 3 volts to the instrument circuit. Until the voltage output drop to 2.1 volts, you will be able to zero the meter needle satisfactorily and make tests with full accuracy. When you cannot zero the needle, it is time to replace the batteries.

Remove screws A-A-A-A Figure A (on Page 9) on sides of top flange and lift out the entire panel, which will also include the protective cover over the instrument components under the panel. Figure C (2). As shown in the Figure C, the batteries are held in the bottom of the case by a clamp secured by screw (3).

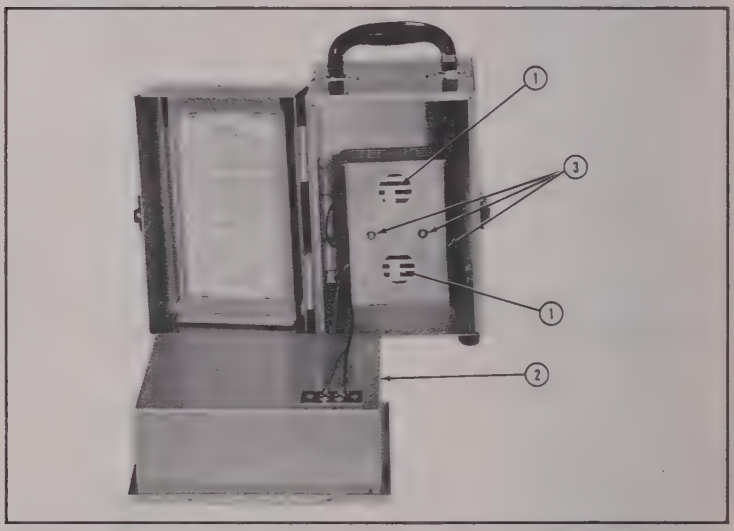



*Figure C—Battery compartment view of Model 201 Vibrotest*

1. Batteries
2. Panel with protective cover
3. Battery clamp with set screw

Remove screw and clamp (3) and batteries (1). Remove wiring and connect new batteries in series, being sure to observe polarity: the red wire from the instrument case goes to the center post of one battery; the black wire to the outside post of the other battery. Jumper wire connects from one minus post to the other plus post.

Replace batteries in case and clamp down, making certain that tops of battery posts are at least one inch from the end of the instrument case.

Replace panel and A screws.

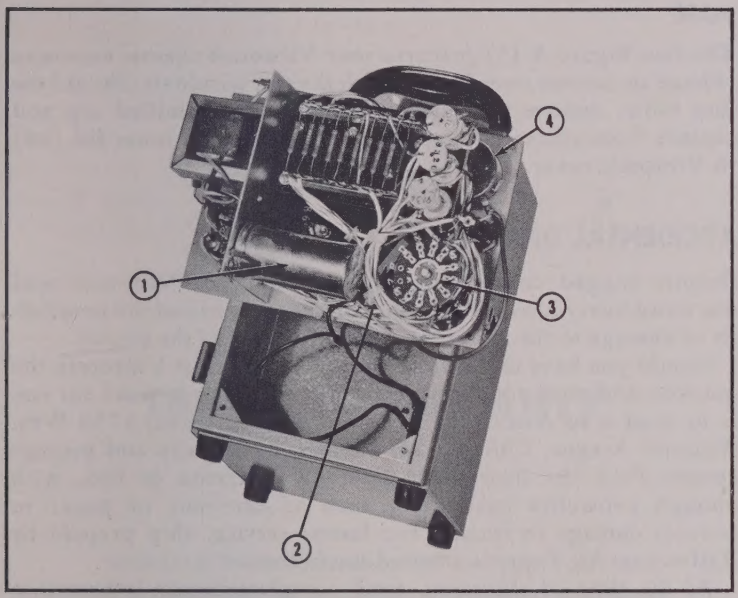



***Figure B—Under panel view of Model 201 Vibrotest***

1. Vibrator
2. Push button switch
3. Range selector switch
4. Zero set potentiometer

## VIBRATOR

When you press the push-button halfway down in the megohm range and hear no vibration hum, and the pointer does not go to zero, change selector switch to ohms range and see if pointer can be zeroed. If not, see *Batteries* above. But if you can zero in the ohms range and not in megohms, a new vibrator may be required.

Remove screws B-B-B-B (Figure A) and lift out panel without protective cover. The vibrator is the plug-in metal cylinder shown in Figure B (1). It can be replaced simply by pulling gently but firmly to remove old vibrator and plugging in new one . . . making sure that socket holes and vibrator pins match without forcing. Check to see that old and new vibrators have the same part number.

## INFINITY POINTER SETTING

When de-energized, the meter pointer on your Vibrotest should rest directly over the "∞" mark at the extreme left of the scale. If you find that the pointer does not take this position, carefully turn set screw in the center of the meter case until the pointer is properly positioned.

## FUSE

The fuse Figure A (5) protects your Vibrotest against excessive voltage or current entering through the test terminals. Should the fuse blow, remove it by unscrewing the black milled cap and replace from spares clipped to the under side of inner lid (10) in Vibrotest cover.

## ACCIDENTAL DAMAGE

Despite rugged construction throughout, your Vibrotest will not stand heavy blows, dropping, or shocks without the possibility of damage to the meter movement or parts of the circuit.

Should you have the misfortune to damage your Vibrotest, the quickest and most economical way to get it back to work for you is to send it to Associated Research, Incorporated, 3758 West Belmont Avenue, Chicago 18, Illinois, for repairs and prompt return. Pack the instrument carefully in carton or box, with enough protective cushioning such as excelsior or paper to prevent damage in transit. For fastest service, ship prepaid by Railway or Air Express, insured for full value.

At the time of shipment, send complete repair information and authority to Associated Research Incorporated either by letter or purchase order giving the following information:

1. Model and Serial Number.
2. Defect noted.
3. When and How the instrument was or will be shipped (waybill number if possible).
4. Address to send invoice.
5. Address to return instrument.

All repairs are on a time and material basis, F.O.B. Chicago, Illinois with terms to credit approved firms, net thirty days.

## REPAIR PARTS

Qualified and properly equipped instrument repair facilities will be supplied parts for repairs to be made in the field. When ordering replacement parts, be certain to include: Model and serial numbers of the instrument, date purchased . . . and if possible, return the old part to us with your order.

## LINE OPERATED VIBROTESTS

Some Vibrotest models feature an electronic circuit in place of the battery operated vibrator power supply. While the test procedures are the same as with battery operated models, special operating instructions are shown on the instruction card and repair information shown for battery operated models will have to be modified.

# FACTORY WARRANTY

**VIBROTESTS are guaranteed free from defects in workmanship and material for one year from date of shipment provided Owner's Registration Card is returned within fifteen days from receipt of unit and there is no evidence of tampering or abuse.**

**This Warranty does not cover tubes, batteries or accessories not of our manufacture.**

**Any unit found defective under this guarantee will be repaired or replaced free of charge if returned to the factory PREPAID and insured.**

**ASSOCIATED RESEARCH, INC.**
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## ELECTRICAL TESTING INSTRUMENTS SINCE 1936

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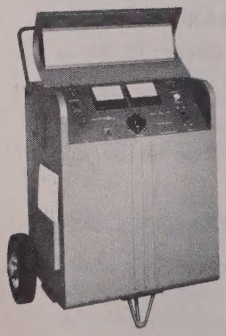
  **Megohmmeters Measure Insulation Resistance**
- **HYPOT®**
  **A-C and D-C High Voltage Test Sets**
- **VIBROGROUND®**
  **Resistance Measurement of Electrical Grounds, Earth Conductivity and Resistance**
- **PHASE SEQUENCE Indicator**
- **"THUMPER" Cable Fault Locator**
- **"DONUT" Instrument Current Transformers**



### HYPOT® Dielectric Strength Testing

**High voltage breakdown and dielectric strength testing of insulating materials in electrical equipment . . . at time of installation and as a periodic maintenance procedure, are provided by the complete line of HYPOT® Test Sets. Application bulletin "Practical HYPOT® Testing" will be sent on request.**

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